Remarks

The application has been carefully reviewed in light of the Office Action dated September 21, 2005. Claims 1-5 and 7-9 are pending. Claim 6 has been canceled. Claims 1 and 7 have been amended in this response. No new matter is believed to be added. In addition, unless a passage of a claim is specifically discussed below in connection with one or more cited references, Applicant respectfully submits that the amendments to the claims should be constructed as being submitted merely to clarify the invention rather than as a limitation submitted to overcome a cited reference.

Rejection under 35 U.S.C. § 103(a)

Claims 1-5, and 7-9 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Young (U.S. Patent No. 5,169,486). Applicant respectfully traverses the rejection and requests reconsideration.

The Office Action fails to establish a prima facie case of obviousness of the subject matter of claims 1 and 7. Courts have generally recognized that a showing of a prima facie case of obviousness necessitates three requirements: (i) some suggestion or motivation, either in the references themselves or in the knowledge of a person of ordinary skill in art, to modify the reference or combine the references' teachings; (ii) a reasonable expectation of success; and (iii) the prior art references must teach or suggest all of the claim limitations. See e.g., In re Dembiczak, 175 F.3d 994 (Fed. Cir. 1999); In re Rouffet, 149 F.3d 1350, 1355 (Fed. Cir. 1998); Pro-Mold & Tool Co. v. Great Lakes Plastics, Inc., 75 F.3d 1568, 1573 (Fed. Cir. 1996). The Young reference fails one or more prongs of obviousness in that, it fails to teach or suggest all of the claim limitations as stated in amended Claim 1.

In the present case, as mentioned above, Young fails to teach or suggest the subject matter of amended Claims 1 and 7. As the examiner suggests, Young discloses a method and apparatus for a vertical Bridgman crystal growth with thermocouples that are placed in different locations in the heater to measure temperatures at the central axis of the crucible. The thermocouples in the Young reference are arranged one above another and measure temperature gradient in the axial direction. They enable the controller to run a program to heat the crucible, establishing an axial temperature gradient therein.

As the Examiner points out, Young discloses a conventional heater in which a crucible is placed. As such, Young discloses a top heater and a bottom heater, whereby the

temperature of the top heater is higher than that of the lower heater. This results in an axial temperature gradient in the crucible beginning with a higher temperature in the upper portion of the crucible, and a lower temperature in the bottom portion of the crucible. In operation, there will be a point in the crucible at which the material within the crucible is at its melting point. Material that exists below that point begin to crystallize, while material above that point are still molten. Lowering the temperature of the bottom heater transitions this point axially upward toward the top heater, so that the phase boundary between the solidified material and the material which is still molten shifts upward, too. In this way, a crystal grows in the crucible.

As is pointed out in Young, the axial temperature gradient can be controlled substantially better by having temperature references at multiple points along the axial length of the crucible. The power in each heater, top and bottom, can be controlled in such a way that the temperature measured along the several points in the axial direction stays within a predetermined temperature profile. As such, the control of the heaters is based upon the temperature measured at all of the reference points.

The discussion thus far has pointed out the state of the art and how the current invention is similar to the Young reference. However, what Young and other conventional furnaces do not teach, is the ability to control the temperature gradient within the crucible in the radial direction. The present invention not only has a top heater and a bottom heater with which to control the axial temperature gradient in the crucible, but it also comprises means to control the radial temperature gradient.

Claim 1, as amended, reads:

> A crystal-growing furnace, in particular a vertical Bridgman or vertical gradient freeze crystal-growing furnace, comprising:
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> a crucible;
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> a top heater positioned substantially proximate a top portion of the crucible;
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> a bottom heater positioned substantially proximate a bottom portion of the crucible, wherein the top heater and the bottom heater are regulated to achieve a predetermined axial temperature gradient within the crucible;

a jacket heater surrounding the crucible coaxially and having a device for regulating the heat output of the jacket heater;

a hollow cylindrical body made of a heat conducting material configured to act as a heat bridge between the crucible and the jacket heater;

at least two thermocouples offset radially relative to one another in a horizontal plane bisecting the jacket heater and the crucible for measuring a radial temperature difference, the heat output of the jacket heater being regulated to achieve a substantially uniform temperature across the portion of the crucible disposed in the horizontal plane.

In Young, the radial temperature gradient is not controlled. Therefore, there is a radial flow of heat such that the isotherms, especially at the phase boundary between the molten and solidified material, are not flat. They are convex or concave, which results in a crystal lattice structure that may contain defects.

Controlling and minimizing or eliminating the radial heat flow within the crucible is achieved by adding a jacket heater around the crucible and measuring the temperature difference with additional thermocouples in at least two points, which are at a radial distance from each other in a horizontal plane, and by controlling the jacket heater in such a way that the temperature difference between these two points becomes essentially zero. This means that heat, which flows out of the furnace in the radial direction, is counter balanced by heat from the jacket heater, which flows in the opposite direction into the furnace, so that the sum of the heat flow is zero. In operation, this would result in the radial temperature gradient being substantially uniformed. Thus, the axial temperature gradient is still controlled by the top and bottom heater by using thermocouples specifically assigned to the top and bottom heaters, respectively.

The control loop of the top and bottom heater is separate from the control loop of the jacket heater. To control the top and bottom heater, it is still necessary to have a predetermined temperature profile. Additionally, the power of the jacket heater is controlled in such a way that the difference between the thermocouples measured at the radially arranged thermocouples becomes zero, regardless of the absolute temperature (*i.e.*, it is a

relative temperature measurement). The jacket heater control loop has no influence on the control of the axial temperature gradient.

The result of controlling the radial gradient is to produce isotherms in the furnace that are flatter and extend in the horizontal direction (perpendicular to the vertical axis of the furnace). Therefore, no stress occurs in the growing crystal, generating very even crystals with fewer defects in lattice structure.

Similarly, Claim 7, which is directed to a method of regulating the radial heat output of a jacket heater, is also not obvious in light of the Young reference.

Claim 7, as amended, reads:

> A method of regulating the radial heat output of a jacket heater surrounding a melting crucible, comprising:
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> determining the temperature difference between two radially offset points within the jacket heater in a horizontal plane intersecting the jacket heater and the crucible; and
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> adjusting the temperature difference thus determined to zero by a corresponding regulation of the heat output of the jacket heater.

As mentioned herein above, the Young reference teaches the control of temperature in a crystal growing furnace by measuring the axial temperature within the crucible and adjusting the top and bottom heaters accordingly. Young does not include, nor does it teach the use of a jacket heater to control the level of heat in an entire plane within the crucible. As discussed above, controlling and minimizing or eliminating the radial heat flow within the crucible is achieved by adding a jacket heater around the crucible and measuring the temperature difference with additional thermocouples in at least two points, which are at a radial distance from each other in a horizontal plane, and by controlling the jacket heater in such a way that the temperature difference between these two points becomes essentially zero. The heat, which flows out of the furnace in the radial direction, is counter balanced by heat from the jacket heater, which flows in the opposite direction into the furnace, so that the sum of the heat flow is zero. Thus, the axial temperature gradient is still controlled by the top

and bottom heater by using thermocouples specifically assigned to the top and bottom heaters, respectively. Young does not disclose a jacket heater. Therefore, Young does not teach all of the elements of Claim 7.

In view of the above, each of the presently pending and newly presented claims in this application is believed to be in immediate condition for allowance. Accordingly, the Examiner is respectfully requested to pass this application to issue.

Payment in the amount of $1,810.00 ($1,020.00 for a three-month extension of time fee and $790.00 for a RCE filing fee) is to be charged to a credit card and such payment is authorized by the signed, enclosed document entitled: Credit Card Payment Form PTO-2038. No additional fees are believed to be due; however, the Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 14-0629.

Respectfully submitted,

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I hereby certify that this correspondence and the documents mentioned therein are being deposited with the United States Postal Service as first class mail in an envelope addressed to: MAIL STOP RCE, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on the date indicated below.

Anthony J. DoVale, Jr.

Anthony J. DoVale, Jr. 3-6-2006
Date